Acceleration of galaxies and Newton's gravity.

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To explain the removal and acceleration of galaxies in our Universe, the law of gravity of I. Newton is sufficient. More precisely, with the elements of Einstein's STR, since the limit of the speed of light will be taken into account. So, here's the proof.

Consider our visible Universe as a cosmological ball, in the center of which our planet Earth is located with us. The distribution of matter in this ball is isotropic and uniform. With distance from the center, that is, from the Earth, the speed of galaxies increases. At the border of this sphere (R), the speed of galaxies will be equal to the speed of light in a vacuum.

Let us recall the well-known fact [1] that the gravitational potential in the center of a homogeneous ball is one and a half times greater than on its surface:

$$V(0) = 1.5 * V(R) = (3 * M * G) / (2 * R)$$

In a gravitational field, the body tries to occupy the position with the lowest potential energy. It is for this reason that when you drop your laptop, it falls to the floor (note, with acceleration g), while its potential energy decreases. It is the same with galaxies: they "fall" over the entire visible Universe, but their acceleration increases.

For the calculation, we will take into account that the visible Universe is a cosmological sphere of a certain radius (R). In the center of such a ball, the gravitational potential will be 1.5 times greater than on its surface. With distance from the center of the ball, the gravitational potential decreases. Therefore, galaxies will "fall" with a certain acceleration in order to take the position with the lowest potential energy.

So, the gravitational potential at the center of the cosmological ball will be equal to:

$$V(0) = (3 * M * G) / (2 * R)$$

where M - is the mass of the cosmological ball,

R - is the radius of the cosmological ball,

G - is the gravitational constant.

The gravitational potential on the surface of the cosmological ball will be equal to:

$$V(R) = (M * G) / R$$

In order to reduce its potential energy (relative to the entire Universe), the galaxy must move in the direction from the center of the ball to its surface, with a certain acceleration (since the galaxy falls into the Universe). Let's define this acceleration. To do this, take into account that the mass of the cosmological ball is:

$$M = (4 * \pi * R^3 * \rho) / 3$$

where ρ - is the density of the cosmological ball.

Then, the potential difference (in the center and on the surface) can be written:

$$\Delta V = V(0) - V(R) = (2 * \pi * \rho * G * R^2) / 3$$

Naturally, the potential difference between the center and an arbitrary position will be equal to:

$$\Delta V = V(0) - V(R) = (2 * \pi * \rho * G * r^2) / 3$$

where r - is the distance from the center of the ball to some arbitrary position.

The work of moving a galaxy of mass m, from the center of the ball to a position remote from the center by r, will be equal to:

$$A(1) = \Delta V * m = (2 * \pi * \rho * G * r^2 * m) / 3$$

But, if we take into account Newton's second law, then the work can be written like this:

$$A(2) = F * r = m * a * r$$

Equating these two works, we can easily obtain a formula for the acceleration of galaxies, which will not depend on the mass of galaxies, since this is a free fall of galaxies onto the cosmological ball.

$$A(1) = A(2)$$

$$(2 * \pi * \rho * G * r^2 * m) / 3 = m * a * r$$

From here, we get the final formula for the acceleration of galaxies in the Universe:

$$a = (2 * \pi * \rho * G * r) / 3$$

In an abbreviated form, you can write:

$$a = K * r$$

where K - is a constant, $K = (2 * \pi * \rho * G) / 3$

r - is the distance from the center of the ball to the position of the galaxy.

Thus, galaxies will accelerate all the time, since their acceleration is directly proportional to the distance from the center of the ball. That is, moving galaxies away from us and accelerating them is the usual work of Newton's gravity. In fact, galaxies fall on the entire visible Universe (cosmological ball), with a certain acceleration, but this acceleration increases.

Amazing! Apples are falling to the Earth, and galaxies are falling to the Universe!

P.S. The potential energy is equal (in magnitude, but negative) to the work done by the gravitational field moving the body.

1. Quora: The force of gravity inside a spherical shell is zero. But presumably space is still curved. Is this correct and if so, how? https://qr.ae/pNS1YL
2. Quora: What are the theories of why the universe is expanding and accelerating? https://qr.ae/pNVoR1